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(54) **Electric lamps having a lens shaped arc or filament chamber.**

(57) An electric lamp (30) having either an arc or a filament as the light source enclosed within a light transmissive chamber (34) whose wall (32) is in the shape of a positive or convergent lens. Such lamps increase the amount of light emitted in a direction normal to the filament or arc axis and when mounted in a reflector result in more light being reflected within the desired beam pattern.

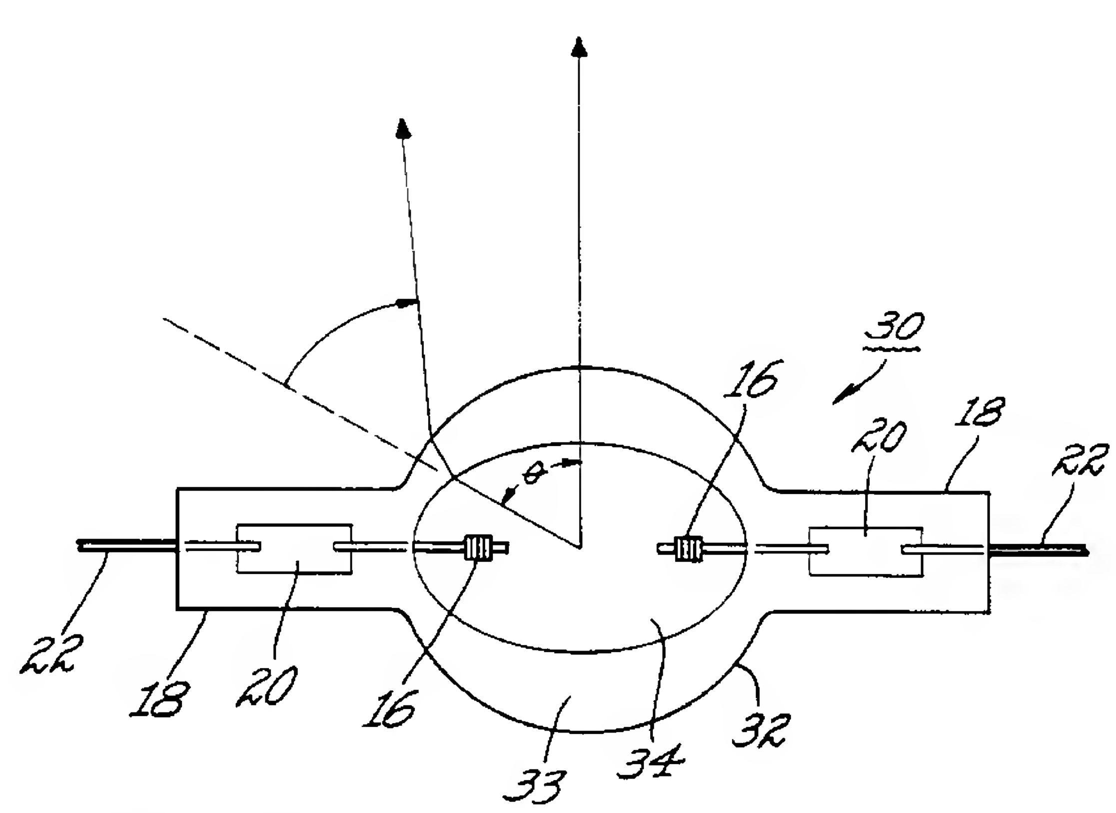


Fig. 1(b)

EP 0 534 606 A1

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to electric lamps having an arc or filament chamber whose wall is in the shape of a convergent lens. More particularly this invention relates to an electric lamp having either an arc or filament as the light source which is enclosed within an arc or filament chamber whose wall is in the shape of a positive or convergent lens for increasing the amount of light emitted in a direction perpendicular to the longitudinal axis of the arc or filament and reducing the amount of light emitted in a direction towards the longitudinal axis of the arc or filament.

Background of the Invention

Arc discharge lamps comprising a vitreous arc tube enclosing electrodes and an arc sustaining fill within are well known to those in the art as are incandescent lamps wherein a tungsten filament is enclosed within a vitreous filament chamber. Such lamps are available in various shapes and sizes with the arc discharge chamber or filament chamber generally being of a cylindrical, spherical or elliptical shape. Except for sodium lamps which employ a ceramic arc chamber, the arc chamber of discharge lamps and the filament chamber of high intensity incandescent lamps are formed from a transparent vitreous material capable of withstanding the high temperature generated by the arc with fused silica (quartz) being the material of choice at the present time. Tungsten-halogen lamps are high intensity filament lamps which are most often used mounted within a reflector for various types of lighting applications, including automotive lighting. Miniature arc discharge lamps are also used within a reflector for automotive and other lighting applications. In lighting applications wherein a lamp is mounted within a reflector, it is desirable for all or at least most of the light emitted by the lamp to strike the reflecting surface and be reflected forward of the reflector in the desired beam pattern, with minimal light distribution outside the beam pattern.

SUMMARY OF THE INVENTION

In one aspect, this invention provides an electric lamp having a light transmissive arc or filament chamber enclosing an arc or filament as the light source within, wherein said chamber has at least one wall at least a portion of which is in the shape of a positive or convergent lens.

In another aspect, the invention provides an electric arc lamp having a pair of electrodes and a suitable fill hermetically enclosed within a light transmissive arc chamber, wherein at least a portion of the wall of said chamber is in the shape of a convergent lens and wherein at least a portion of light emitted by said arc is refracted by said lens shaped arc chamber wall.

In a further aspect, the invention provides an electric incandescent lamp having a light transmissive filament chamber having a filament hermetically enclosed within wherein at least a portion of the wall of said chamber is in the shape of a convergent lens and wherein at least a portion of light emitted by said filament is refracted by said lens shaped portion of said wall.

The present invention relates to an electric lamp having an arc discharge or filament as the light source within an arc or filament chamber, wherein the wall of the arc or filament chamber is in the shape of a positive or convergent lens. This increases the amount of light emitted by the lamp in a direction normal to the longitudinal axis of the lamp and reduces the amount of light emitted in a direction towards the longitudinal axis of lamp. When lamps of this invention are mounted in a reflector, the positive or convergent lens shape of the arc or filament chamber wall increases the amount of light reflected from the reflecting surface into the desired beam pattern and reduces the amount of light outside the desired beam pattern. This is a result of more of the light emitted by the lamp striking the reflecting surface and being projected forward of the reflector within the desired beam pattern. Thus, one embodiment of this invention relates to a reflector and lamp combination wherein an arc discharge lamp or incandescent lamp is mounted within a reflector wherein the wall of the arc discharge chamber or filament chamber has a positive lens shape. Using a lamp of the present invention in this combination produces more reflected light than would be possible with a conventional arc lamp or filament lamp of the same light emissivity, but wherein the wall of the arc or filament chamber is of a relatively uniform thickness.

By convergent or positive lens is meant a lens which converges light. Examples of such lenses include a plano-convex lens, a positive meniscus lens and a bi- or double-convex lens. Arc discharge lamps according to this invention have been made with the arc chamber wall having both plano-convex lens shapes and positive meniscus lens shapes. In the context of the lamps of the present invention, positive shape means that the thickness of the arc chamber or filament chamber wall is greater towards the middle than at the ends thereof. Those skilled in the art will understand that in some embodiments it will be undesirable or impractical for the arc chamber wall to be thickest exactly at the middle. Thus, in double ended lamps of this invention, a section of the arc or filament chamber wall taken in a direction parallel to the arc or filament will have a generally plano-convex, double convex or positive meniscus lens shape. In single ended and electrodeless lamps, such as those

disclosed, for example, in U.S. Patents 4,409,516; 4,620,130; 4,723,092; 4,876,483 and 4,894,590 those skilled in the art will recognize yet other possibilities exist for placement of the positive lens portion of the arc or filament chamber wall.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1(a) schematically illustrates a miniature arc lamp of the prior art; Figures 1(b), 1(c) and 1(d) schematically illustrate and miniature arc lamps of the invention, and Figure 1(e) schematically illustrates a filament lamp of the invention.

Figure 2 schematically represents an arc lamp of the prior art in 2(a) and an arc lamp of the invention in 2(b), both mounted within a reflector.

Figure 3 is a perspective view of an automotive headlamp employing a miniature arc lamp of the invention.

Figure 4 schematically represents an experimental apparatus used to obtain the data of Figure 5.

Figure 5 is a graph of intensity of lamp light output as a function of emission angle of a lamp of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Turning now to Figure 1, in Figure 1(a) a typical prior art miniature metal halide lamp 10 is schematically illustrated comprising fused silica envelope 12 having an internal arc chamber 14 which encloses a pair of electrodes 16 and a fill including mercury, at least one metal halide and inert starting gas (not shown). Arc chamber wall 13 is of uniform thickness and is shown in a generally elliptical shape, although it could be an ovoid shape, a spherical shape, a combination of shapes, etc., as is well known to those skilled in the art. Electrodes 16 are hermetically sealed in arc chamber 14 by means of seal portions 18 at each end of the arc chamber which are pinched or shrunk around molybdenum foil seals 20 connected at one end to the electrodes and at the other end to outer leads 22. The two arrows depict light radiation emitted from the midpoint of the arc (not shown) which would be at the midpoint between the two electrodes. One arrow illustrates light being emitted in a direction perpendicular or normal to the longitudinal axis of the lamp (and arc) and the other arrow illustrates light being emitted at an angle ⊖ in a direction towards the longitudinal axis of the lamp.

Figure 1(b) schematically illustrates a miniature double ended metal halide arc lamp 30 of the present invention which also comprises a fused silica envelope 32 having hermetically sealed arc chamber 34 enclosing electrodes 16 and a suitable fill hermetically sealed therein by means of shrink or pinch seals 18. Wall 33 of envelope 32 is in the shape of meniscus lens which is a positive or convergent type of lens. Seals 18 hermetically seal molybdenum sealing foils 20 connected at one end to electrodes 16 and at the other end to outer leads 22 as with the prior art arc lamp. As with the prior art lamp, one arrow illustrates light radiation emitted by the arc in a direction normal or 90° to the longitudinal axis of both the arc and lamp. The other arrow illustrates light emitted at an angle ⊖ which is identical to the angle ⊖ of the prior art lamp illustrated in Figure 1(a), but wherein the positive or convergent shape of the arc chamber wall 33 bends the light radiation emitted by the arc at the ⊖ angle in a direction more normal to the longitudinal axis of the arc and lamp as it passes through wall 33.

This converging or collimating of the light radiation emitted by lamps of the invention is also shown in Figures 1(c), 1(d) and 1(e). Thus in Figure 1(c) lamp 40 comprises fused silica envelope 42 wherein the wall 43 of arc chamber 44 is in the shape of a plano-convex lens. In Figure 1(d) lamp 50 is shown comprising fused silica envelope 52 wherein wall 53 of arc chamber 54 is in the shape of a double convex lens. In both of these embodiments the light emitted by the arc at the ⊖ angle is bent in a direction more normal to the longitudinal axis of the lamp and arc by the convergent lens shape of the arc chamber wall. Figure 1(e) schematically illustrates another embodiment of a lamp of the invention wherein the source of light is a tungsten filament 65 enclosed within filament chamber 64 wherein chamber wall 63 is in the shape of meniscus lens such as is shown in Figure 1(b). In this latter embodiment a shorter filament (as shown) is preferred over a long filament, because the lensing effect is more effective for a shorter light source than for a longer light source whether such source be an arc or a filament. The ideal light source for maximum lensing effect is a point, but this doesn't exist in practicality. For example, if the filament chamber is elliptical, the length of the filament will preferably be shorter than the distance between the two focal points of the ellipse. Also, the lamp may be a conventional incandescent lamp or it may be a tungsten-halogen lamp wherein one or more halogen compounds are enclosed within the filament chamber as is well known to those skilled in the art. In a further embodiment the outer surface of the filament chamber may be coated with a multi-layer light interference coating made of alternating layers of high and low refractive index materials such as tantala and silica.

Double ended lamps according to this invention have been made with both plano-convex lens shapes and positive meniscus lens shapes by means of a process employing a gathering-molding process disclosed in column 8 of U.S. Patent 4,810,932, in column 9 of 4,389,201 and in a paper by Hansler and Davenport, "A Hew Low Wattage Metal Halide Lamp Process", J. IES, p. 109-122 (Fall, 1985), the disclosures of which are incorporated herein by reference. These references disclose gathering-molding proc-

ess which may be employed to make lamps out of high temperature glass or fused silica or synthetic quartz. This gathering and blow molding process is performed on a glass lathe which is controlled by a computer to ensure conformance to the specifications that have been set for the inside and outside surface profiles of the arc or filament chamber. In such a process a hollow cylindrical piece of synthetic quartz or fused silica tubing is loaded into a glass lathe with a seal made to both ends of the tubing to ensure that a positive gas pressure can be applied inside the tubing during rotation, heating and molding of the tubing. As the lathe collet rotates, a gas torch is directed toward that portion of the tubing at which it is desired to form the arc or filament chamber. The torch is designed to heat only a short length of the tubing and it is driven along the length of the tubing while one end of the tubing is slowly pushed towards the other end which is fixed in the collet. This causes the quartz thickness to be increased where the torch flame is directed. A combination of positive pressure inside the tubing and the lower viscosity at the inside surface of the tubing due to the lower inside surface temperature maintains or minimizes the collapse of the interior of the tubing during the forming process. In this manner the quartz wall thickness can be built up from about 1 mm thick to several mm thick when employing, for example, quartz tubing typically 3 x 5 x 150 or similar (ID x OD x length in mm). When the desired gather has been achieved the torch is shut off and moved out of the work area. Also, during this process it is advantageous to have a cooler gas stream located at either side of the torch flame in order to maintain that portion of the chamber/tubing cool adjacent the hot portion while the gathering is occurring in the area being heated by the flame. After the gather process is complete a molding torch typically longer than the arc or filament chamber and wider than the tubing is employed to heat the entire chamber and when the proper temperature is reached a mold is indexed into position over the chamber and enclosed around the chamber. A positive pressure is then applied, via head and tail stock seals, to the inside of the chamber forcing the hot quartz to expand to the inside shape of the mold. After the molding is complete the mold and torch are removed from the work area and the fully molded tube is ready for finishing.

Turning to Figure 2, both a prior art lamp 10 and a lamp 30 of the present invention are shown having an elongated stem portion 19 forming one end of the vitreous lamp envelope mounted (by means not shown) into a base portion 74 of a reflector 70 having light reflecting surface 72 on the inside thereof. Conductor 71 is electrically connected to lamp outer lead 22, extends through hole 73 in reflector 70 and is connected to a ground (not shown). Similarly, high voltage insulated conductor 75 is connected by means not shown to the other outer lead of lamp 10 and lamp 30 and exits base 74 from which it is connected to a high voltage current supply which is not shown. In operation, visible light radiation, *a*, emitted by the arc tube in a direction normal to the longitudinal axis of the lamp strikes the reflective surface of the reflector and is reflected and projected forward in the desired beam pattern. With the prior art lamp 10, visible light radiation depicted as *b* and *c* emitted from the center of the arc chamber off normal to the longitudinal lamp axis at angles γ_1 and γ_2, respectively, continue in the γ_1 and γ_2 directions and are not reflected forwardly off reflective surface 72. Instead, visible light radiation *b* and *c* miss the reflective surface 72 and exit in a direction more to the side of the reflector instead of being projected forward of the reflector in the desired beam pattern as with light radiation, *a*. In contrast, employing a lamp 30 of the present invention wherein the arc chamber wall is in the form of a positive lens results in the light radiation emitted from the center of the arc at angles γ_1 and γ_2 to be convergently refracted by the positive lens shape of the arc chamber wall so that they exit the arc chamber at angles γ_3 and γ_4 which are smaller than γ_1 and γ_2. As a consequence, the light radiation *b* and *c* in this embodiment emitted at angles γ_3 and γ_4, respectively, strike the reflecting surface 72 of the reflector as part of the desired beam pattern. Thus, by using a lamp having an arc or filament chamber wall in the shape of a convergent or positive lens, a greater amount of light emitted by the lamp is reflected from the reflecting surface and projected forward of the reflector within the desired beam pattern and not lost as radiation emitted outside the desired beam pattern.

Turning to Figure 3 another embodiment of the present invention is illustrated wherein lamp 30 (Figure 1(b)) is mounted horizontally within an automotive headlamp assembly 80 comprising a double truncated, parabolic reflecting member 82 with a lens 84 secured to the front section of the reflector member, a connection means 86 secured at the rear section of the reflector member for connection to a power source and arc lamp 30 mounted within. Lamp 30 is mounted within reflector 82 by means of electrically conductive metal support leads 96 and 97 which are welded at one end to lamp leads 22 and connected at their other end to pins 98 for connection to a source of electricity. Lamp 30 is mounted vertically in reflector 82 with its longitudinal axis normal to longitudinal axis 88 of the reflector and top and bottom flat truncated portions 90 and 92, while being generally parallel to parabolic reflecting portion 94. Thus, the positive cross section of the arc chamber wall increases the amount of emitted light directed to the parabolic reflecting surface. The interior surface (not shown) of the parabolic reflecting portion 94 is a light reflecting surface for reflecting light emitted by lamp 30 forward of the reflector in a predetermined beam pattern. Mounting lamp 30 of the invention in the reflector 82

in the fashion shown and described increases the lamp light output that is reflected forward of the reflector, while at the same time reducing the amount of light emitted by the lamp in a direction that will strike the truncated portions 90 and 92 of the reflector, which light is not projected forward into the desired beam pattern and is thereby wasted.

The foregoing embodiments are meant to be illustrative and not limiting examples of the practice of the invention. Thus arc lamps useful in the practice of the invention are not limited to those containing metal halide, but include mercury, xenon, etc., arc lamps. Further, the invention may also be practiced with single ended arc and filament lamps and also with electrodeless lamps as discussed under Summary of the Invention. In the case of a single ended lamp comprising an arc or filament chamber having a top, sides and bottom, wherein the leads connected to the filament or electrode extend through a hermetic seal in the bottom, all or a portion of the top and/or side walls of the chamber could be in the form of a positive lens shape as could all or a portion of the wall(s) of an electrodeless lamp arc chamber. Further, even with the double ended examples illustrated and described above, not all of the arc chamber wall need be in the shape of a convergent lens.

Figure 4 schematically illustrates an experimental arrangement used to measure the degree of lensing or light collimation that occurred in arc lamps of the invention having walls in the shape of a positive or convergent meniscus lens, such as is shown in Figure 1(b), compared to similar types of prior art lamps such as is shown Figure 2(a) wherein the wall of the arc chamber had a relatively uniform cross section. Each arc tube or lamp to be measured was mounted on a rotary table (not shown), with the midpoint of the arc chamber 50 centimeters from a light detecting photodidode 100, which in turn was electrically connected to a volt meter 102. Each arc tube to be measured was mounted on a rotary table (not shown) with its longitudinal axis horizontal. The rotational axis of the table was coincident with the middle of the arc chamber of the arc tube. The light detecting photodiode or photocell, corrected for human eye sensitivity, was a United Detector Technology PIN10AP. The active area of the photocell was directed toward the center of the lamp arc chamber. The voltage measured across the photodiode was proportional to the amount of light striking it. This configuration permitted rotation of the arc tube while it was energized in order to vary the viewing angle of the arc tube by the photodiode detector and maintain the distance from the center of the arc chamber to the detector constant. Thus the amount of light directed toward the detector from the lamp could be determined as a function of various viewing angles. Metal halide lamp arc tubes representative of the prior art had an electrode gap 5 mm long hermetically enclosed, along with metal halide and mercury and an inert starting gas, in a 9 x 7 mm ellipsoidal arc chamber. The arc chamber wall was of uniform thickness and was 0.6 mm thick. These lamps were made from a 2.4 x 4 mm fused silica or quartz stock. Lamps according to the present invention had a similar fill with an electrode gap of 4.2 mm in an ellipsoidal arc chamber having dimensions 9 x 6.7 mm with a 2.7 mm inside diameter and a meniscus lensing wall cross section of the arc chamber. These lamps were made from tubing stock having a dimension of 1.8 x 3.2 mm. In both of these lamps the 7 mm or 6.7 mm dimension was the maximum outside diameter of the arc chamber. The given dimensions of the tubing stock from which the lamp was made are the inside and outside diameters, respectively, of the tubing. The thickness of the arc chamber wall of the lamps of the present invention was 2.0 mm at its thickest point in the middle of the arc chamber and gradually reduced to about 1.3 mm at each end of the arc chamber.

Figure 5 graphically displays intensity of light output as a function of emission angle of lamps of the present invention and lamps of the prior art that were measured using the apparatus schematically shown in Figure 4. The results shown in Figure 5 dramatically illustrate the invention in that the lamps of the present invention having an arc chamber whose wall is in the shape of a positive or convergent lens significantly collimates the light emitted from the arc chamber so that more of the light is emitted in a direction perpendicular to the longitudinal axis of the arc. All of the curves in Figure 5 were normalized to the peak intensity of each lamp, because the different designs produced different lumens. The relative light intensity was determined by dividing the light intensity exhibited at each viewing angle by the maximum intensity observed and this is plotted in Figure 5 as a function of viewing angle. The relatively flat intensity profile exhibited by the lampe of the prior art indicates a lack of any lensing effects. The abrupt drop in intensity at the 90° viewing angle was due to the light being blocked by the seal at the end of the lamp in an end-on view by the photodiode detector. The curves of the lamps of the invention show that the amount of light radiated by the lamps at large angles relative to the non-lensing prior art lamps were substantially reduced.

Claims

1. An electric lamp having a light transmissive arc or filament chamber enclosing an arc or filament as the light source withn, wherein said chamber has at least one wall at least a portion of which is in the shape of a positive or convergent lens.

2. An electric arc lamp having a pair of electrodes

and a suitable fill hermetically enclosed within a light transmissive arc chamber, wherein at least a portion of the wall of said chamber is in the shape of a convergent lens and wherein at least a portion of light emitted by said arc is refracted by said lens shaped arc chamber wall.

3. An electric incandescent lamp having a light transmissive filament chamber having a filament hermetically enclosed within wherein at least a portion of the wall of said chamber is in the shape of a convergent lens and wherein at least a portion of light emitted by said filament is refracted by said lens shaped portion of said wall.

4. The lamp of Claim 1 wherein at least a portion of light emitted by said lamp is refracted by said wall lens.

5. The lamp of any preceding claim wherein said positive or convergent lens shape is a meniscus lens, a plano-convex lens or a double-convex lens.

6. The lamp of Claim 5 wherein the maximum thickness of said lens-shaped chamber wall is greater towards the middle of said chamber than at the end.

7. The lamp of Claim 1 being an electrodeless arc lamp.

8. The lamp of Claim 1 being an arc discharge lamp having said arc chamber enclosing a pair of electrodes within.

9. The lamp of Claim 3 being an incandescent lamp wherein said filament chamber enclosed a filament within.

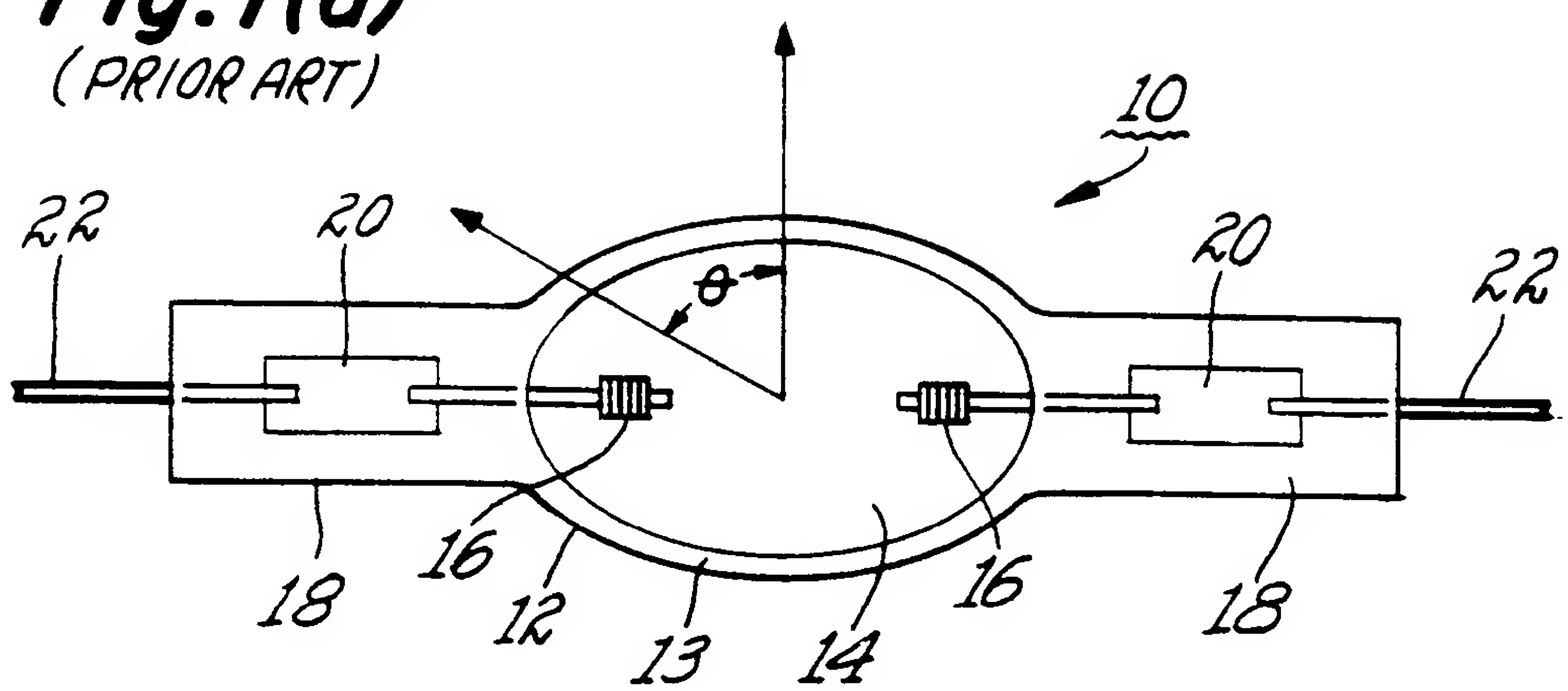
10. The lamp of Claim 2 or 3 wherein at least a portion of said refracted light is emitted in a direction more towards normal to the arc axis.

11. The lamp of Claim 3 being a double ended lamp and said chamber and filament each having a longitudinal axis parallel to each other.

12. In combination, a reflector and an electric lamp mounted within said reflector, said lamp having an arc or filament chamber enclosing an arc or filament as the light source within, wherein said chamber has at least one wall at least a portion of which is in the shape of a positive or convergent lens and wherein at least a portion of light emitted by said source is refracted by said lens shaped portion of said wall.

13. In combination, a reflector and a double ended electric lamp mounted within said reflector, said lamp having an arc or filament chamber enclosing an arc or filament as the light source within, wherein said chamber wall is in the shape of a positive or convergent lens and wherein at least a portion of light emitted by said source is refracted by said lens shaped wall.

Fig. 1(a)
(PRIOR ART)



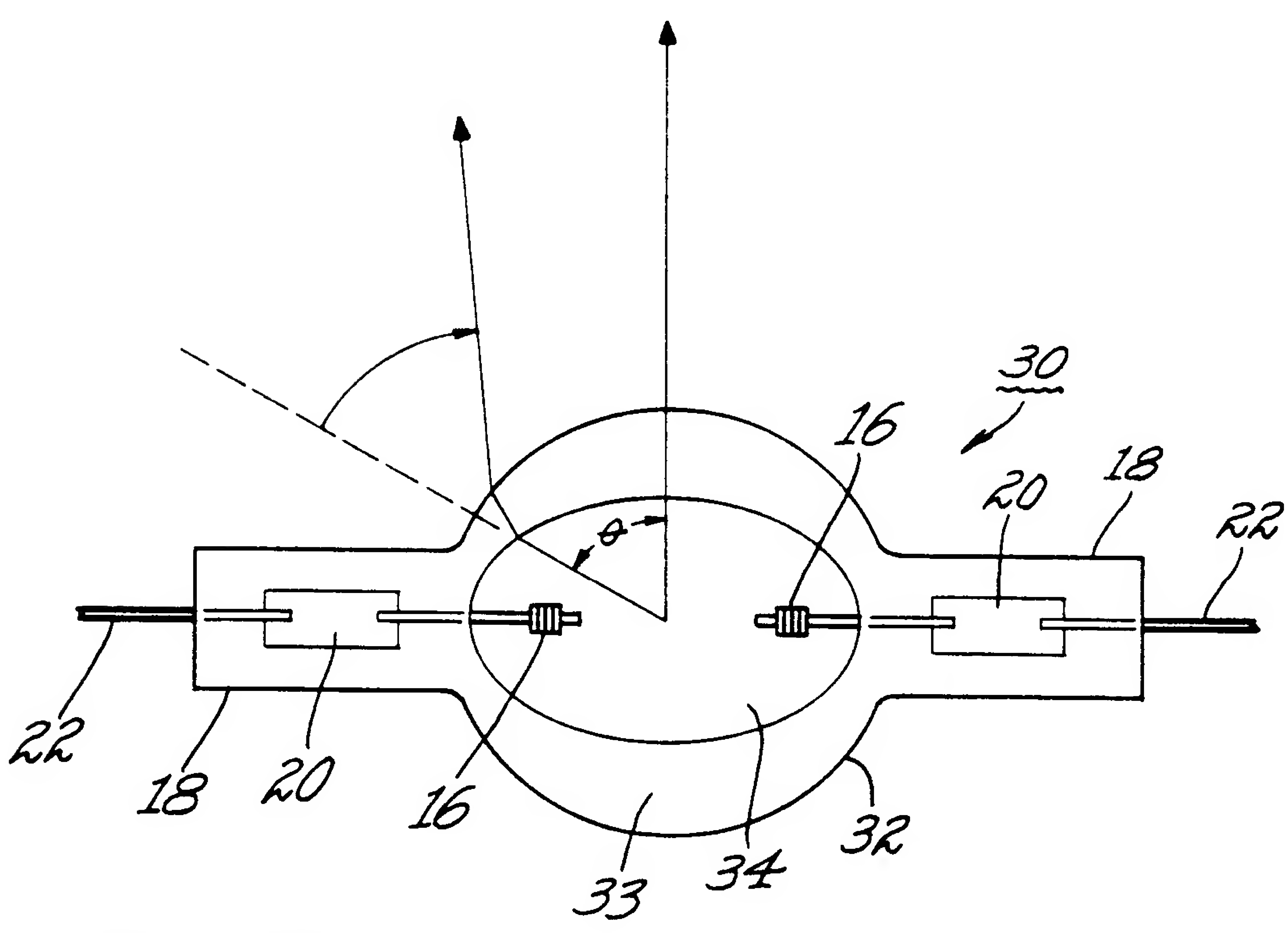


Fig. 1(b)

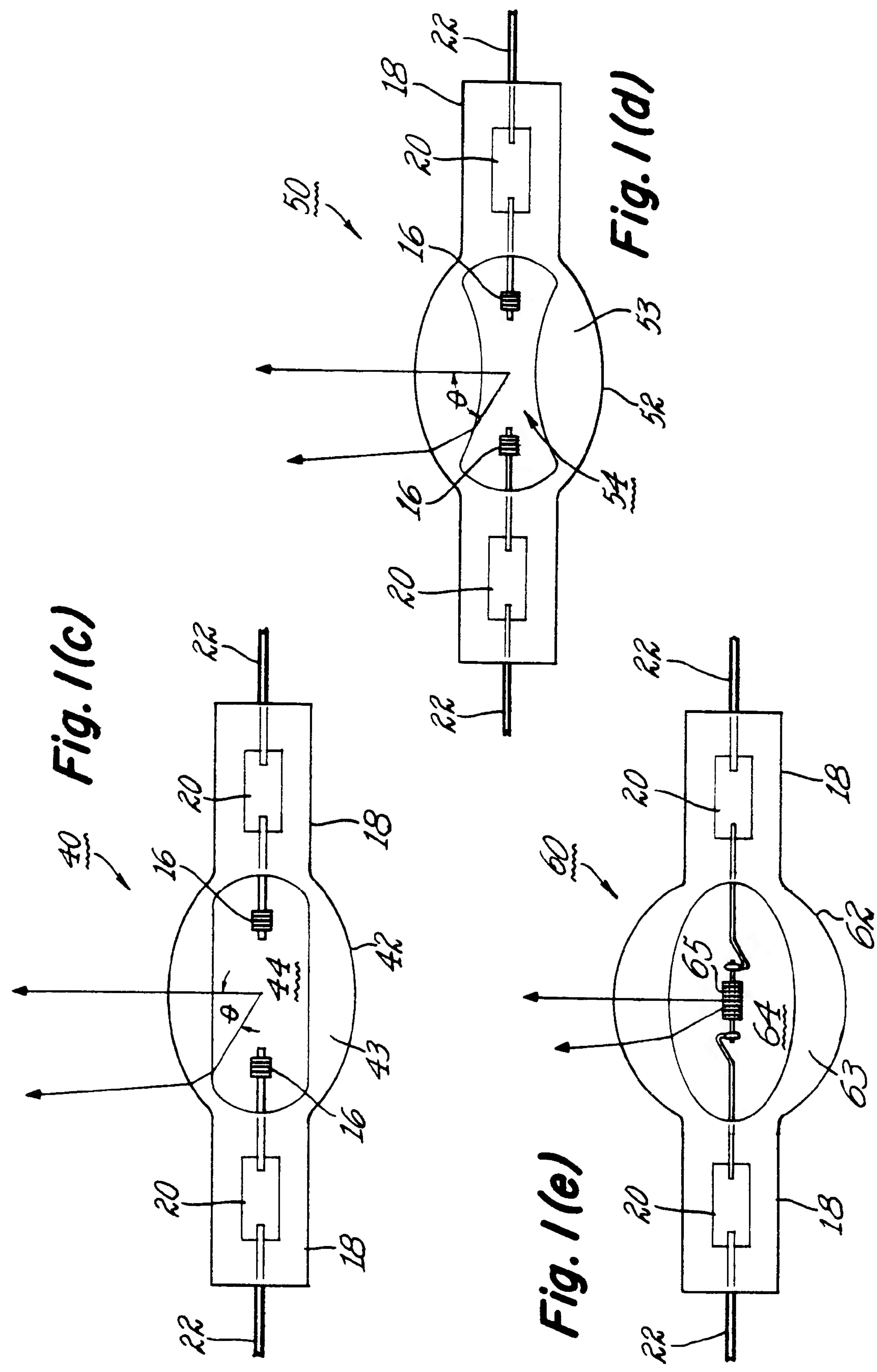


Fig. 1(c)

Fig. 1(d)

Fig. 1(e)

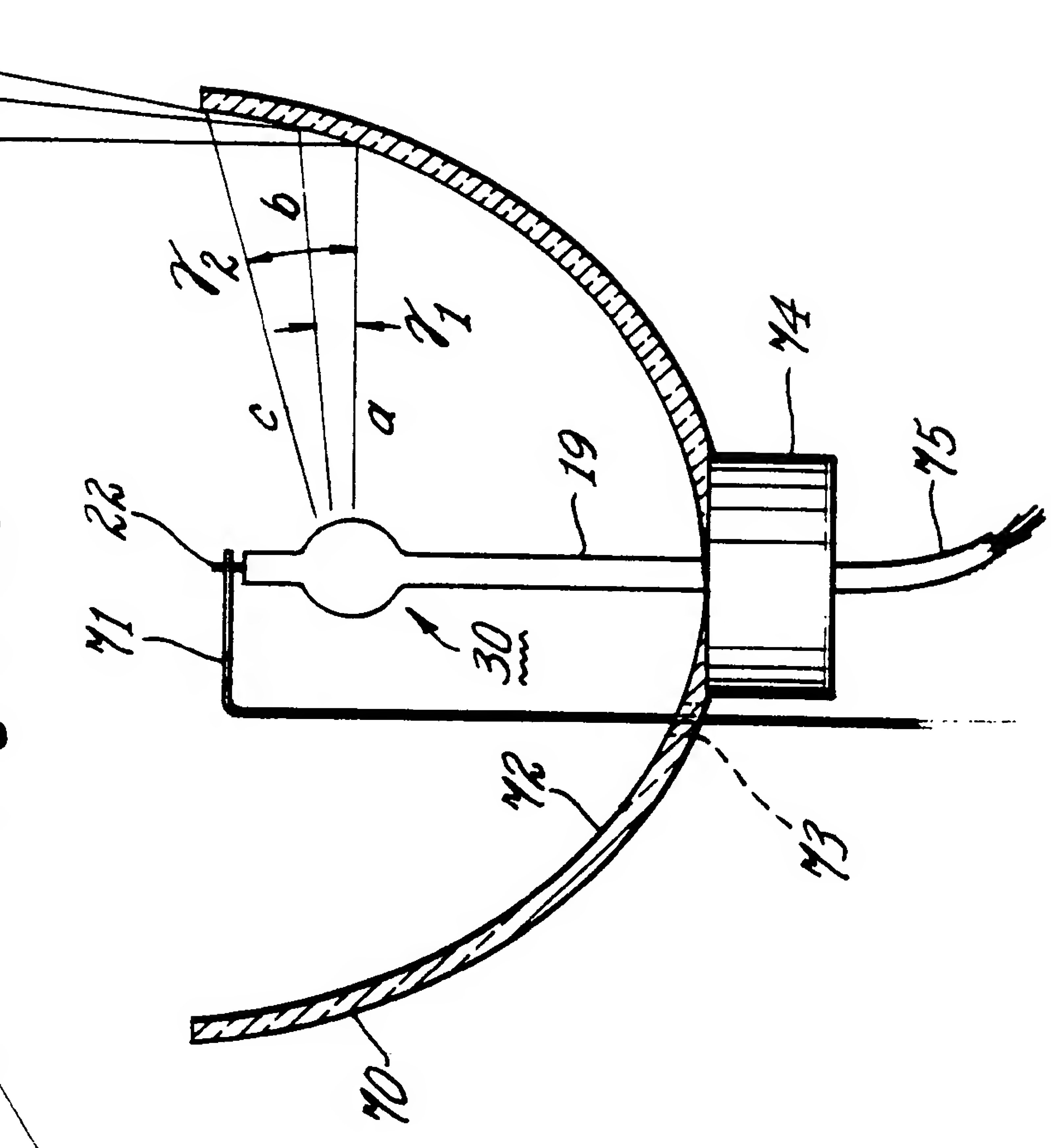


Fig. 2(b)

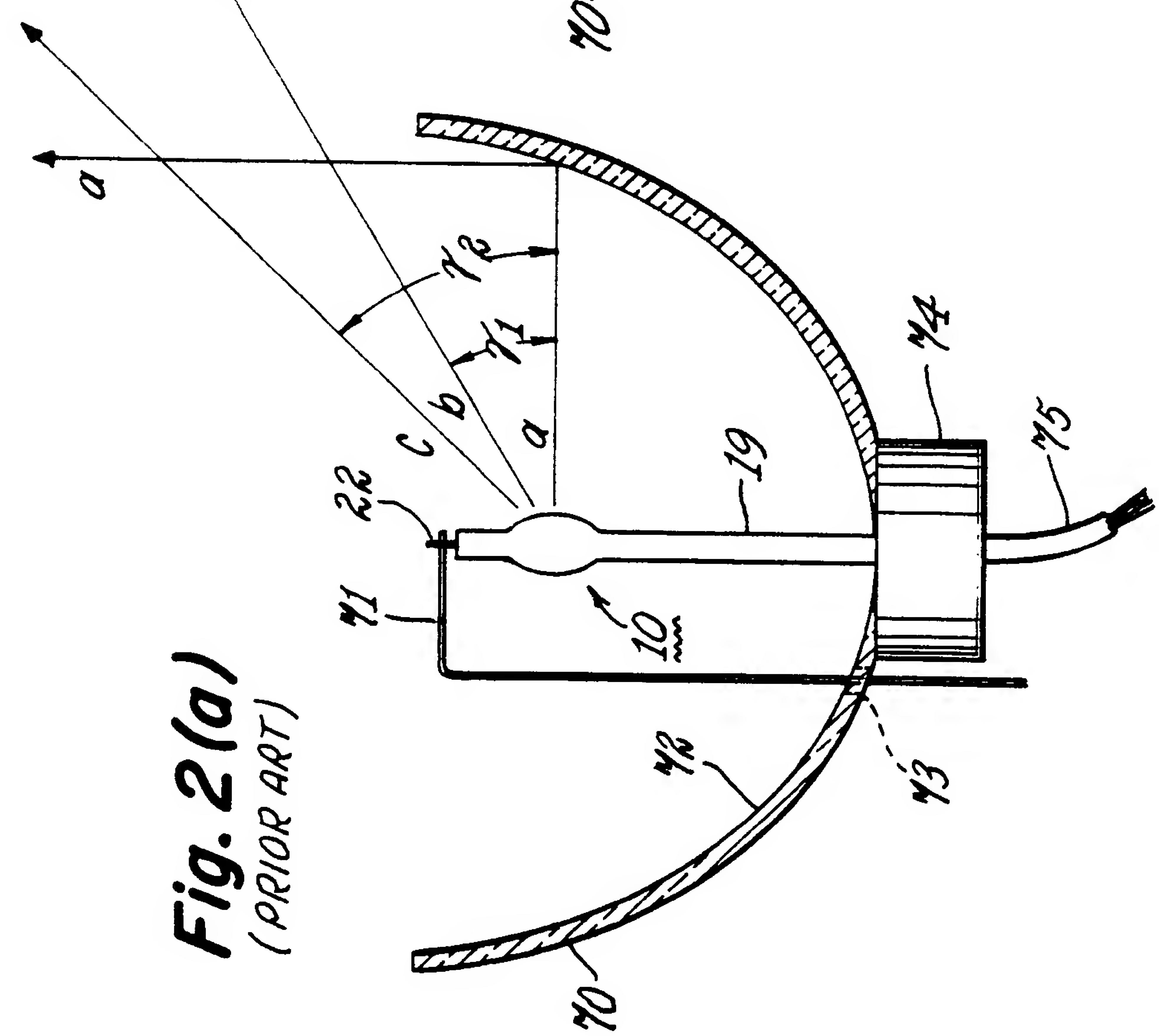


Fig. 2(a)
(PRIOR ART)

Fig. 3

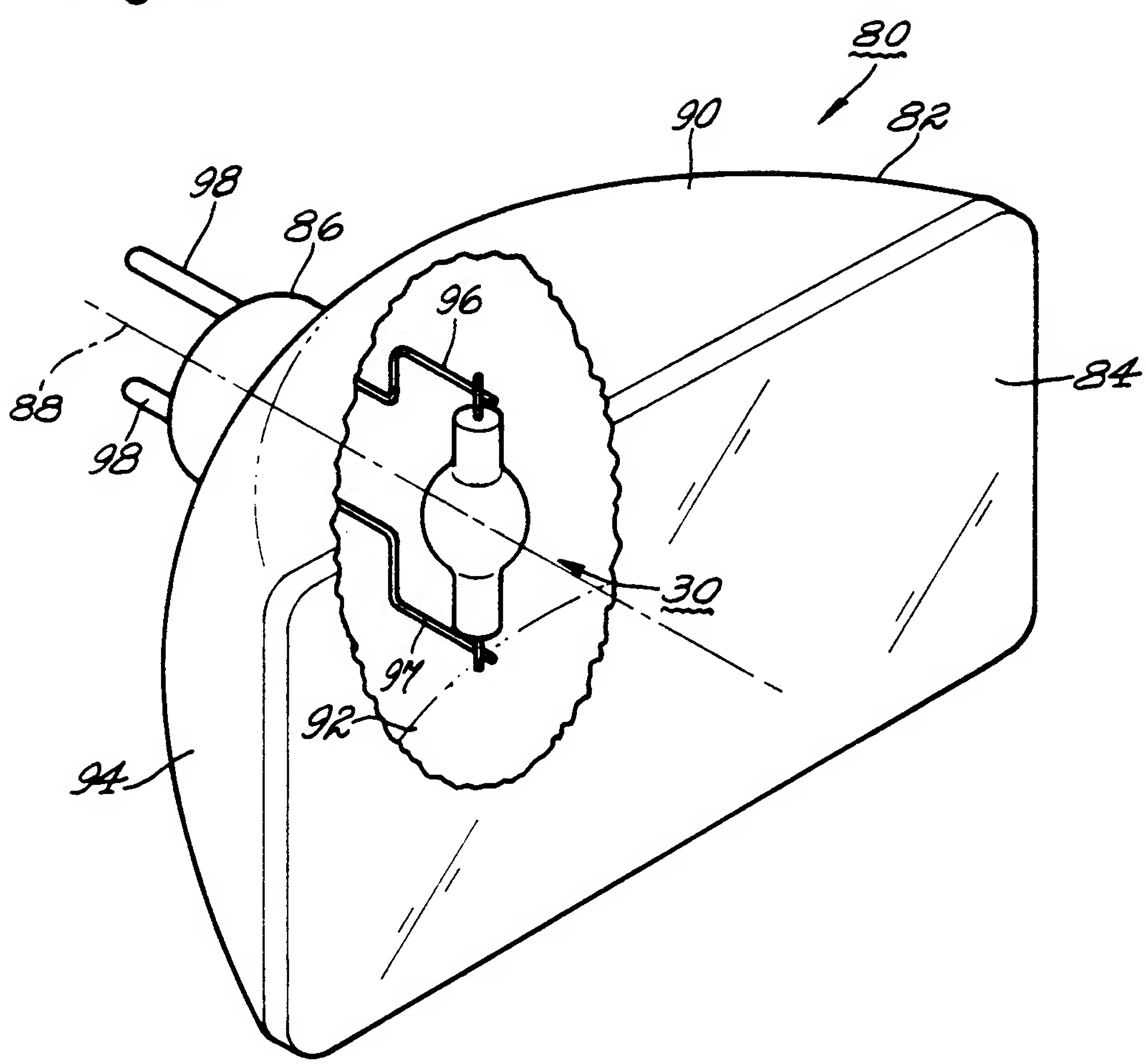
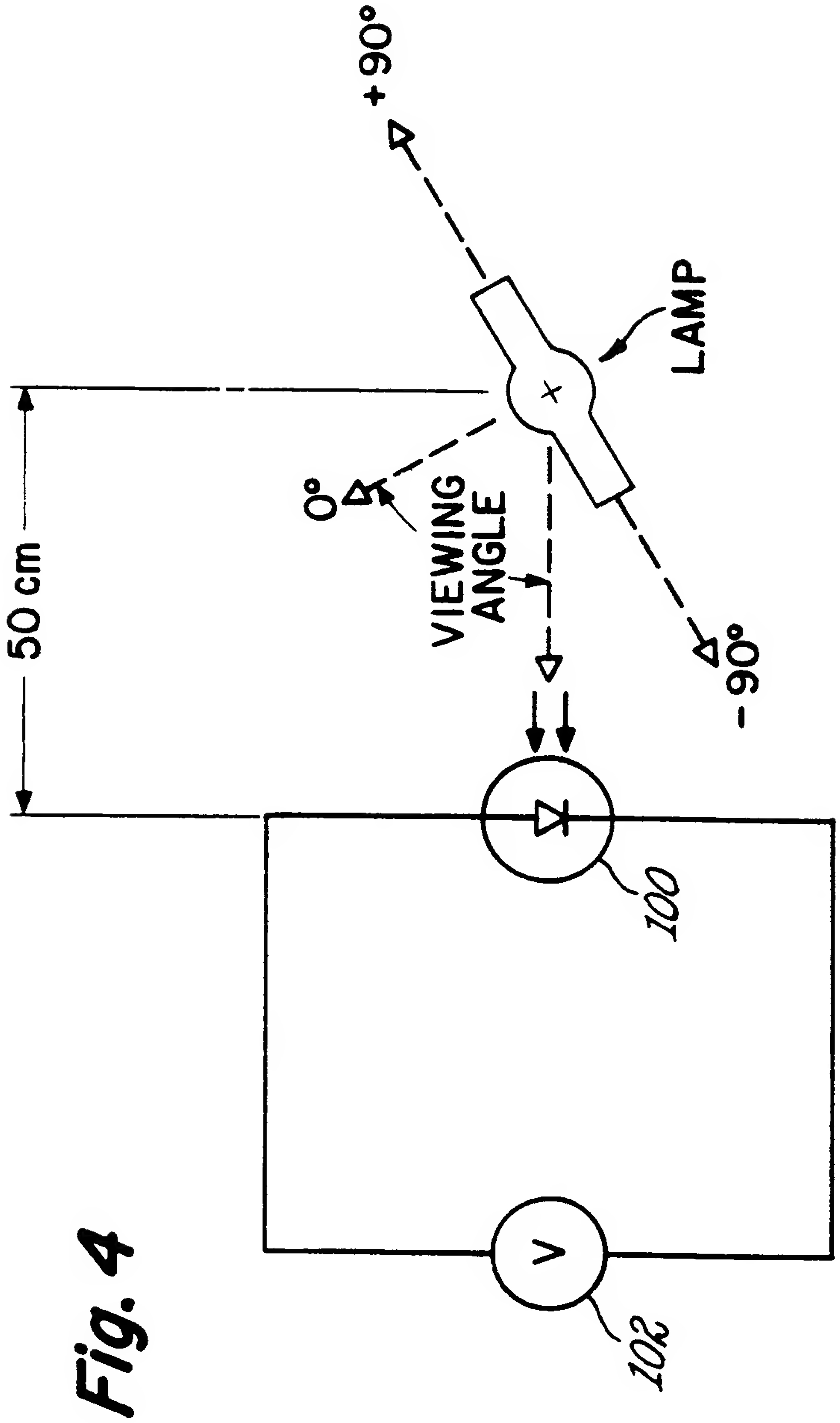
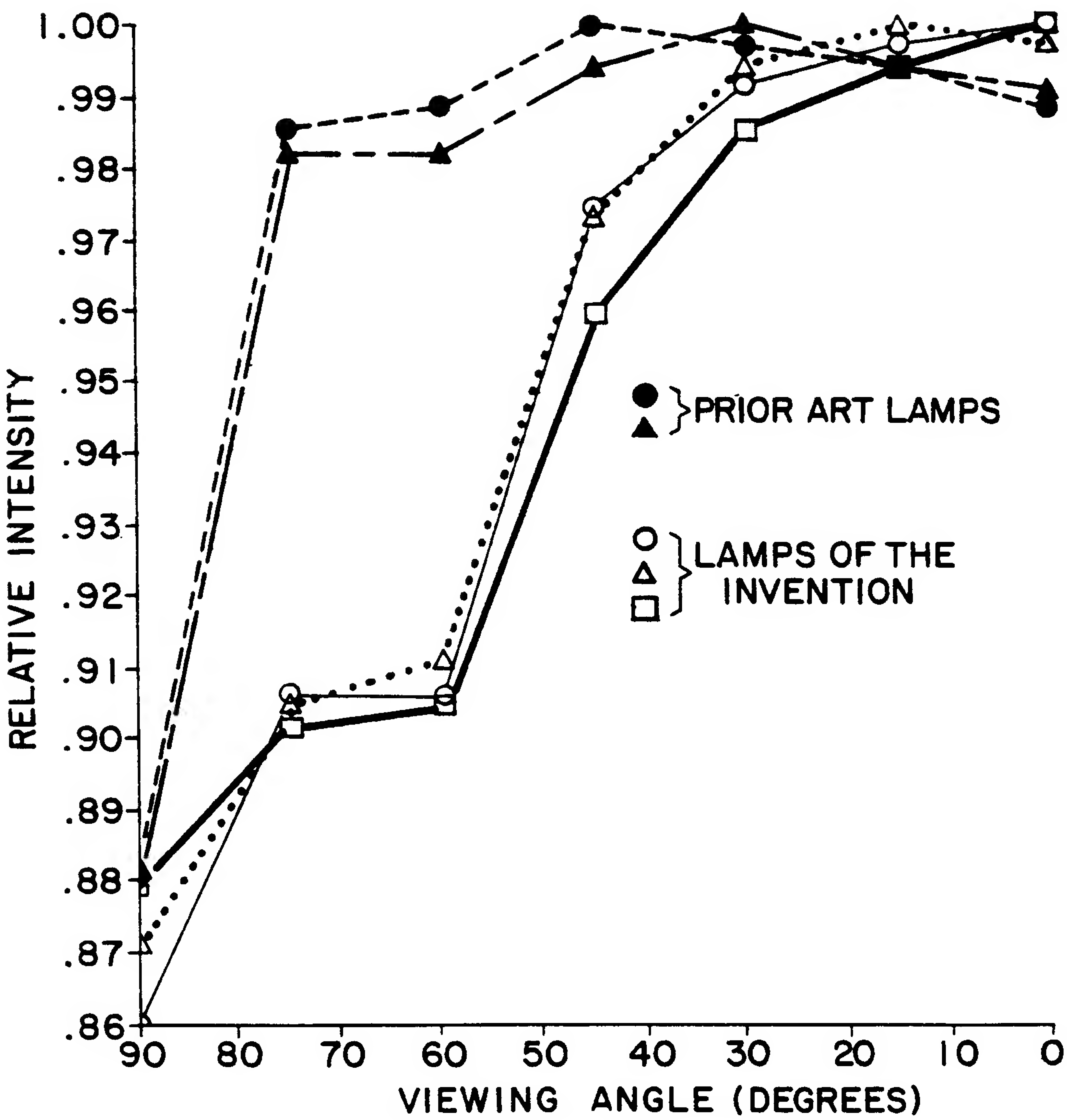


Fig. 4



TOP VIEW OF EXPERIMENT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RELATIVE INTENSITY
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VIEWING ANGLE (DEGREES)
PRIOR ART LAMPS
LAMPS OF THE INVENTION

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number

EP 92 30 7677
Page 1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X Y	US-A-3 457 447 (MENELLY ET AL.) * abstract; figures 10-12 * * column 1, line 19 - line 31 * * column 2, line 43 - line 48 * * column 3, line 19 - line 24 * ---	1,2,4,5,8,10,12,13 1,7	H01J61/02
X	DE-A-3 617 662 (HEIMANN GMBH) * claim 5; figures 2,3 * ---	1,2,4-6,8	
X A	FR-A-829 585 (MONTAIN) * page 1, line 1 - line 9 * * page 1, line 18 - line 21 * * page 3, line 3 - line 16; figures 1,2,9-11 * ---	1,3-6,9-12 13	
X	GB-A-950 283 (SASSMANNHAUSEN) * page 1, line 9 - line 16; figures 2,3,5,6 * ---	1,3-6,9,10,12	**TECHNICAL FIELDS SEARCHED (Int. Cl.5)** H01J H01K
X	US-A-1 961 964 (DODGE) * page 1, line 30 - line 32 * * page 1, line 89 - line 98; figures 5-7 * ---	1,3-6,9,12	
X	PATENT ABSTRACTS OF JAPAN vol. 1, no. 145 (E-407)28 May 1986 & JP-A-61 008 843 (TOSHIBA K.K.) 16 January 1986 * abstract * --- -/--	1,3-7	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 DECEMBER 1992	MARTIN Y VICENTE M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

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EUROPEAN SEARCH REPORT

Application Number

EP 92 30 7677
Page 2

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	PATENT ABSTRACTS OF JAPAN vol. 12, no. 80 (E-590)12 March 1988 & JP-A-62 219 457 (CANON INC) 26 September 1987 * abstract *	1,7	

			TECHNICAL FIELDS SEARCHED (Int. Cl.5)

The present search report has been drawn up for all claims

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THE HAGUE	22 DECEMBER 1992	MARTIN Y VICENTE M.

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L : document cited for other reasons

& : member of the same patent family, corresponding document

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